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Project Summary

Effects of Particulate Air Pollution on Asthmatic Subjects

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While much remains to be understood, individuals with respiratory disease appear to be affected by high levels of air pollution as indicated by subjective reports, clinic and hospital visits, and morbidity. Suspended particulates make up a substantial part of urban air pollution, and specific components of particulates, such as sulfates and nitrates, when combined with moisture, form acids with properties potentially irritating to the lung. The available research literature has not clearly implicated the components of suspended particulates which do exert an immediate effect upon the health status of individuals with respiratory disease.

The present study focuses upon the acute or short-term effects of suspended particulates upon asthmatic individuals. It has incorporated several unique features. Extensive medical characterization of each subject's asthma was available, and individuals with other respiratory or medical conditions were not included. Recent advances in methods of particulate measurement, based upon dichotomous sampling of particulates via virtual impactor techniques, were incorporated in the study. The daily health status of the asthmatic subjects was considered to be a concept that is best defined by employing three different types of measurements, selected in order to triangulate on the more immediate health effects of air pollution upon the asthmatic subjects.

Of all the atmospheric pollutants studied, only the fine IPM nitrate fraction gave any indication of a relationship to the health status of ashtmatic subjects.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The time period of the study considered here is from January through March 1979, when the pollutants to be measured were at their highest and most fluctuating levels in Denver, where the study took place.

Screening of the subjects prior to study included: confirmation of perennial asthma symptoms, methacholine inhalation challenge, twice-daily peak expiratory flow rate during a 5- to 7-day period, medical history, physical examination, prick tests, chest x-ray, electrocardiogram, and use of the Panic-Fear Personality Scale to identify and exclude patients with excessively high characterological anxiety known to be associated with medication overuse and arbitrary use.

Of 41 well-characterized asthmatic subjects selected for the study, 24 met the criterion of 60% complete data within the target period January 1979

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through March 1979, after the elimination of daily measurement periods when upper respiratory infections were reported and periods when subjects were out of the Denver metropolitan area for more than three hours during a 12-hour measurement period. All subsequent analyses focused upon these 24 subjects, 9 males and 15 females. All lived within 2.5 miles of one of two air quality monitoring stations. All were taking a theophylline preparation or an oral beta agonist on a regular schedule as a basic bronchodilator, while 8 subjects also supplemented this medication regimen with daily or alternate-day oral corticosteroids. In addition, all subjects took an aerosolized bronchodilator on a discretionary, as-needed basis to relieve episodes of acute breathing difficulty.

Study Parameters

Exposure measurements recorded at the two monitoring stations included: fine fractions ($< 2.5\ \mu m$) and coarse fractions (between $2.5\ \mu m$ and $15\ \mu m$) of inhaled particulate matter (IPM), including mass, nitrates, and sulfates, sulfur dioxide, carbon monoxide, ozone, ambient temperature, and barometric pressure. Subject responses to exposure were evaluated by obtaining twice daily measurements of three health status variables: peak expiratory flow rate (PEFR) measured by Mini-Wright Peak Flow Meter, usage of as-needed aerosolized bronchodilators recorded by nebulizer chronolog with concurrent manual recording of time and amount for each use, and subject rating of nine discrete symptoms of breathing difficulty.

The objectives of the statistical analyses were to test the study's null hypotheses pertaining to the effects of air pollution upon each of the three health status measurements, namely that:

- Elevated pollution levels do not significantly *increase* the severity of reported airways obstruction symptoms,
- Elevated pollution levels do not significantly *decrease* peak expiratory flow rates, and
- Elevated pollution levels do not significantly *increase* the usage of as-needed aerosolized bronchodilators.

These hypotheses were tested by LEAPS AND BOUNDS Multiple Linear Regression Analyses (including correlation analyses, multiple linear regression analyses for individuals, and aggregate multiple linear regression analyses for groups) and by the application of a random effects model.

Results

For both air quality monitoring stations, average values for fine and coarse IPM were high and variable during the months of January and February compared with March levels. In general, the East Denver station had notably higher 7 AM fine IPM mass levels than the West Denver station, a difference that was particularly noticeable in January and February. For the IPM components, fine and coarse IPM sulfates and fine IPM nitrates were also generally higher for the 7 AM collection period, and higher at the East than the West Denver station. For these variables, a continuous decrease in monthly mean levels was discernible from January through March. Average coarse IPM nitrate levels were generally low throughout the study period and at both stations. Mean carbon monoxide and sulfur dioxide levels reflected certain tendencies similar to those of the IPM variables, showing higher levels at the East Denver station. These levels generally were decreasing from January through March. By contrast, mean levels of ozone, while consistently low, show a definite increase across months. Morning temperatures rose from an average of -9°C to +1°C, while average evening temperatures increased from -7°C to +5°C during the same period. Monthly average morning and evening barometric pressures were consistently at approximately 29.9 in. Hg across the three months.

A correlation matrix for the environmental and meteorologic variables for both stations during the 71 days available for the three-month period studied shows that fine and coarse IPM mass shared approximately 25% common variance. Fine IPM mass was also moderately related to the gaseous air quality variables (inversely to ozone) and to fine IPM sulfate and nitrate levels at both stations. The relationships of coarse IPM mass to fine and coarse IPM sulfates and nitrates were consistently low. Fine IPM mass values were always correlated with temperature, coarse IPM mass levels were nearly independent of temperature.

While certain moderate relationships exist among the health status measurements, there is actually notable variation in the magnitude of the relationships. The average relationships between nebulizer usage and the objective measurements of airways obstruction were always negative and quite low. Nebulizer usage was somewhat more reliably related to subjective ratings of airways obstruction than to PEFR, indicating a tendency for subjects to use their nebulizers more frequently when they reported more airways obstruction.

Univariate correlational analyses showed an inconsistency in the pattern of correlations among the health status measurements across both stations. This inconsistency obtained for each of the environmental and meteorologic variables, although Fisher's tests indicated that a significant relationship obtained among the associated p-values for the correlations for coarse IPM sulfates and fine IPM nitrates. On the basis of these preliminary analyses, *both* fractions of IPM sulfates and nitrates were retained for the subsequent multiple linear regression analyses, while gaseous air quality, meteorologic, and fine and coarse IPM mass variables were all excluded.

LEAPS AND BOUNDS multiple linear regression analyses by individual subjects included no predictor variables that improved upon no regression or the best univariate regression. This was true for each health status measurement. Most notably, IPM measurements of fine and coarse sulfates and nitrates rarely predicted the health status of individual subjects and generally were inconsistent in direction among individuals when they appeared at all. In the aggregate LEAPS AND BOUNDS multiple linear regression analyses, the 12 subjects assigned to each station were considered as a group. For each of the three health status measurements there are four aggregate regressions defined by two stations and two time periods. In all cases, the model conformed to the analyses for individuals, using the previous health status measurement, and fine and coarse IPM sulfates and nitrates as the predictor variables. Only two of the IPM components appeared as best predictors in these analyses. Coarse IPM sulfates were positively associated with PEFR for the 7 AM period and negatively associated with nebulizer usage for the 7 PM period at the West Denver station.

The paradoxical nature of these relationships and the failure of coarse IPM sulfates to appear within the regressions at the East Denver station or at the other time period suggest that the relationships are due to chance. Fine IPM nitrates appeared as a best predictor three times, negatively for 7 AM PEFR, positively for 7 PM nebulizer usage at the West station, and positively for the 7 PM subjective report of airways obstruction at the East station. Results of application of the Random Effects Model support the LEAPS AND BOUNDS multiple linear regression analyses, suggesting that fine IPM nitrates may have influenced nebulizer usage and symptom reports, while no other air pollutant adversely affected health status.

Conclusion

Of all the atmospheric pollutants studied, only the fine IPM nitrate fraction gave any indication of a relationship to the health status of the asthmatic subjects. In the final series of analyses, increased fine IPM nitrates tended to be associated with increased subjective reports of airways obstruction and increased aerosolized bronchodilator usage when all subjects were combined. Because of the number of comparisons made, these results, while in the expected direction indicative of an effect, may well be attributed to chance. We did, however, select a conservative approach to help guard against chance results by using two-tailed statistical tests for clearly directional *a priori* hypotheses. Neither any other fraction of IPM, any gaseous air quality variable, nor any meteorologic measurement produced any consistent effect on the health status of asthmatic subjects. The determination of any threshold at which a change in health status occurs is thus precluded by the nature of these results.

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***Dorothy Calafiore** is the EPA Project Officer (see below).*
The complete report, entitled "Effects of Particulate Air Pollution on Asthmatic Subjects," (Order No. PB 81-190 514; Cost: $9.50, subject to change) will be available only from:
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